Theoretical Physics Institute
University of Minnesota

TPI-MINN-00/52-T
UMN-TH-1928-00
November 2000

Decays of b hadrons and a possible new four-quark interaction

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Abstract

A possibility is considered of explaining the low experimental value of the ratio of the lifetimes $\tau(\Lambda_b)/\tau(B_d)$ by a new 'centiweak' four-quark interaction, i.e with a strength on the order of $10^{-2}\,G_F$. It is noted that the considered interaction can also improve agreement with the data on low semileptonic branching ratio $B_{sl}(B)$ in B meson decays with a simultaneous slight decrease in the prediction for the average charm yield in those decays. The proposed new interaction modifies within the present experimental limits the predictions for differences of lifetimes among B mesons, and can thus be probed by more precise data on these differences. A sample model is briefly discussed, where the new interaction arises through a weak SU(2) singlet scalar field with quantum numbers of a diquark.

1 Introduction

The central value of the experimental data on the ratio of the lifetimes [1] $\tau(\Lambda_b)/\tau(B_d) = 0.79 \pm 0.05$ persistently defies an explanation within the present theoretical understanding of differences of inclusive decay rates of heavy hadrons in the Standard Model, which is highly unlikely to produce a theoretical prediction for this ratio outside the range $\tau(\Lambda_b)/\tau(B_d) > 0.9$ (for a review see e.g. Ref.[2], and also the most recent review [3]). If this conundrum is not resolved by improved experimental data, we might be compelled to look for an explanation beyond the Standard Model. In fact, the decays of b hadrons are a likely place where effects of new physics may show up. Indeed, the dominant weak interaction in these decays is suppressed by $|V_{cb}| \approx 0.04$, thus new interactions with a 'centiweak' strength of about $10^{-2}\, G_F$ may lead to sizeable relative effects in the b decays. This paper hypothesizes on an impact on these decays of one such 'centiweak' four-quark interaction with the chiral structure

$$(\overline{c}_L\, \Gamma\, b_R)(\overline{d}_L \Gamma' u_R) \ , \tag{1}$$

where Γ and Γ' generically stand for spin and color matrices. The presence of a right-chiral u quark prevents an interference between the new hypothetical term and the weak interaction in the 'parton' decay of the b quark, so that the new interaction contributes only quadratically to the overall total non-leptonic decay rate. On the other hand, the chirality of light quarks is broken in hadrons, so that the differences of inclusive decay rates of individual hadrons, arising from the effects of a spectator u quark receive a linear contribution from the new interaction through its interference in the spectator effects with the standard weak interaction. Thus the impact of the new interaction on the differences of the inclusive decay rates can be comparable with their values in the standard calculation, while the effect in the overall non-leptonic decay rate would amount to only about 15 %. It can be noted that an increase of the non-leptonic 'parton' decay rate of such magnitude is not unwelcome in view of the long-standing problem (see e.g. in Refs. [4, 5, 3]) of a somewhat low semileptonic branching ratio $B_{sl}(B)$.

In what follows it will be shown, that with the strength of the new interaction corresponding to such moderate increase in the 'parton' non-leptonic decay rate, one can achieve an enhancement of the Λ_b decay rate from an additional contribution to the 'weak scattering' $u\, b \to c\, d$. The specific estimate of the enhancement is, as usually, complicated by the uncertainty in hadronic matrix elements of four-quark operators. For reasonable values of those matrix elements a 'sample' estimate of the enhancement amounts to approximately

5%. Although the magnitude of the enhancement does not look excessively large by itself, one should take into consideration that it essentially equals to the calculated effect within the Standard Model. Simultaneously with this enhancement of the Λ_b decay, the new interaction additionally suppresses (within the current experimental errors) the inclusive decay rate of the B^- meson through an additional contribution to the negative 'Pauli interference'. Thus a larger, than conventionally predicted, ratio of the lifetimes $\tau(B^-)/\tau(B^0)$, may be viewed as a test of the considered mechanism with a new interaction. The connection between the enhancement of the Λ_b decay and the suppression of that of the B^- could be avoided if the suggested interaction included a right-chiral d_R quark rather than u_R. The reason to choose the structure as shown in eq.(1) is that it can be realized by exchange of a colored scalar field ϕ: $b_R\, u_R \to \phi \to c_L\, d_L$, which is a singlet under the electroweak SU(2) symmetry. Thus as 'unnatural' as it would be, it is perfectly consistent to consider the situation where only the quark flavors indicated in eq.(1) are involved in a new interaction, mediated by ϕ. In this case, to the best of the knowledge of the author, an interaction of this type with a centi-weak strength does not contradict the known phenomenology of the flavor dynamics. On the contrary, an interaction involving a right-chiral d quark instead of u_R would arise from an exchange of a scalar, which is a component of an SU(2) doublet, and one would have to deal with potentially unwanted consequences of the interactions induced by the other component of the doublet.

In what follows only the flavor structure as shown in eq.(1) is considered, containing all four possible spin and color combinations. In Sect.2 the expressions are derived for the effects of the suggested interaction in the 'parton' decay rate of the b quark, and in the spectator effects in Λ_b and in B mesons. The numerical estimates of these effects are presented in Sect.3, followed by Sect.4, containing the discussion and summary.

2 Effects of the new interaction in decays of b hadrons

The Lagrangian for the hypothetical new interaction with the chiral structure shown in eq.(1) can be written in the following general form

$$L_{cw} = \frac{G_F\, V_{cb}}{\sqrt{2}}\, [\, 2\, h_1\, (\overline{c}\, (1+\gamma_5)\, b)(\overline{d}\, (1+\gamma_5)\, u) + \frac{1}{2}\, h_2\, (\overline{c}\, \sigma_{\mu\nu}\, (1+\gamma_5)\, b)(\overline{d}\, \sigma^{\mu\nu}\, (1+\gamma_5)\, u)$$
$$+2\, h_3\, (\overline{c}\, (1+\gamma_5)\, u)(\overline{d}\, (1+\gamma_5)\, b) + \frac{1}{2}\, h_4\, (\overline{c}\, \sigma_{\mu\nu}\, (1+\gamma_5)\, u)(\overline{d}\, \sigma^{\mu\nu}\, (1+\gamma_5)\, b)\,] + h.c.\ , \qquad (2)$$

where $\sigma_{\mu\nu} = i\,(\gamma_\mu \gamma_\nu - \gamma_\nu \gamma_\mu)/2$, and the overall factor $G_F\, V_{cb}/\sqrt{2}$ is chosen in such a way that the dimensionless constants $h_1, \ldots, h_4$ describe the strength of the interaction relative to the dominant four-quark interaction in nonleptonic b decays:

$$L_w = \frac{G_F\, V_{cb}}{\sqrt{2}}\,[\,\frac{C_+ + C_-}{2}\,(\overline{c}\,\gamma_\mu\,(1-\gamma_5)\,b)(\overline{d}\,\gamma_\mu (1-\gamma_5)\,u) + \frac{C_+ - C_-}{2}\,(\overline{c}\,\gamma_\mu\,(1-\gamma_5)\,u)(\overline{d}\,\gamma_\mu (1-\gamma_5)\,b)\,] + h.c.\ , \tag{3}$$

with $C_\pm$ being the well-known short-distance renormalization coefficients:

$$C_- = C_+^{-2} = \left[\frac{\alpha_s(m_b)}{\alpha_s(m_W)}\right]^{4/\beta_0}\ , \tag{4}$$

and β_0 is the coefficient in the QCD beta function. The value of β_0 relevant to b decays is $\beta_0 = 23/3$. The terms in both the standard weak interaction Lagrangian (3) and the hypothetical one in eq.(2) are assumed to be normalized at $\mu = m_b$, so that the constants h_A as well as $C_\pm$ stand for their values at this normalization point: $h_A = h_A(m_b)$, $C_\pm = C_\pm(m_b)$, and the appropriate normalization of the four-quark operators is also implied.

2.1 Effect in the total nonleptonic decay rate

As is already discussed, due to extremely small mass of the u quark, there is essentially no interference between the 'centiweak' and the standard weak decay amplitudes in the total 'parton' decay rate of the b quark. The effect of the new interaction is thus quadratic in the coefficients h_A, and is given by

$$\frac{\delta\Gamma_{nl}(b)}{\Gamma_{nl}^{(0)}(b)} = |h_1|^2 + 3\,|h_2|^2 + |h_3|^2 + 3\,|h_4|^2 + \frac{2}{3}\,\mathrm{Re}\,(h_1\, h_3^* + 3 h_2\, h_4^*)\ , \tag{5}$$

where $\Gamma_{nl}^{(0)}(b)$ is the standard 'parton' nonleptonic decay rate for the process $b \to c\, d\, \overline{u}$:

$$\Gamma_{nl}^{(0)}(b) = \frac{G_F^2\,|V_{cb}|^2 m_b^5}{64\,\pi^3}\left[(1-\frac{m_c^4}{m_b^4})(1-8\,\frac{m_c^2}{m_b^2}+\frac{m_c^4}{m_b^4}) - 24\,\frac{m_c^4}{m_b^4}\,\ln\frac{m_c}{m_b}\right]\ , \tag{6}$$

with the QCD radiative corrections being omitted in both eq.(5) and eq.(6).

2.2 Interference with standard weak interaction in decays of Λ_b

The current theoretical approach to the effects of spectator quarks in inclusive decay rates of heavy hadrons is based on the operator product expansion in powers of m_Q^{-1} of the 'effective

Lagrangian' corresponding to the absorptive part of the correlator:

$$L_{eff} = 2\,\mathrm{Im}\left[i\int d^4x\, e^{iqx}\, T\left\{L_{int}(x), L_{int}(0)\right\}\right] \ , \tag{7}$$

where L_{int} is the part of the (weak) interaction Lagrangian responsible for the type of the decay under consideration. In terms of L_{eff} the inclusive decay rate of a heavy hadron H_Q is given by[1]

$$\Gamma_H = \langle H_Q|\, L_{eff}\, |H_Q\rangle \ . \tag{8}$$

The leading term in the OPE describes the 'parton' decay rate of a heavy quark, which is the same for all hadrons carrying the given heavy quark flavor, while the differences between decay rates of individual hadrons are described by the terms relatively suppressed by m_Q^{-2}: $L_{eff}^{(2)}$, and m_Q^{-3}: $L_{eff}^{(3)}$. In the standard analysis (see e.g. in Ref.[2]) the contribution of $L_{eff}^{(2)}$ to the difference of lifetimes of Λ_b and B^0 amounts to only about 1%, while the $L_{eff}^{(3)}$ term enhances the decay rate of Λ_b relative to B by at most 6-7%.

The hypothetical new interaction in eq.(2) gives rise to a cross term in the correlator (7) between L_w and L_{cw}, giving an additional contribution $\delta L_{eff}^{(3)}$ to $L_{eff}^{(3)}$. For simplicity only the part of $\delta L_{eff}^{(3)}$ relevant to the shift of the decay rates of the hyperons in the triplet (Λ_b, Ξ_b^0, Ξ_b^-) is written here. In separating out this part one takes into account that in these baryons there is no correlation of the heavy quark spin with the spin degrees of freedom of the light quarks. Technically this reduces to the following replacement for the bilinear in the heavy quark operator matrix:

$$\overline{b}_{i\,\alpha} b^{j\,\beta} \to \left(\frac{1+\gamma^\mu u_\mu}{4}\right)_\alpha^\beta \left(\overline{b}_i b^j\right) \ , \tag{9}$$

where α, β are Dirac spinor indices, i, j are the color indices, and u_μ is the 4-velocity of the baryon. Furthermore, the average value of the parity-violating operators over the hadrons are vanishing, thus the only relevant structures reduce to those containing the operators $(\overline{b}b)(\overline{u}u)$ and $(\overline{b}_i b^j)(\overline{u}_j u^i)$. Also the 'hybrid' renormalization factors are not included here, following the convention that the operators, as well as the constants h_a in the new interaction (2) are normalized at $\mu = m_b$. After these remarks, the relevant part of the effective Lagrangian reads as

$$\begin{aligned}&\delta\Gamma(H_b) = \langle H_b|\delta L_{eff}^{(3)}|H_b\rangle = \frac{G_F^2 m_b^2 |V_{cb}|^2}{4\pi} \times \\ &\{\ \mathrm{Re}\left[C_+(h_1+h_3-3h_2-3h_4) + C_-(h_1-h_3-3h_2+3h_4)\right] \langle H_b|(\overline{b}b)(\overline{u}u)|H_b\rangle + \\ &\mathrm{Re}\left[C_+(h_1+h_3-3h_2-3h_4) - C_-(h_1-h_3-3h_2+3h_4)\right] \langle H_b|(\overline{b}_i b^j)(\overline{u}_j u^i)|H_b\rangle\ \}\ .\end{aligned} \tag{10}$$

[1]We use here the non-relativistic normalization for the *heavy* quark states: $\langle Q|Q^\dagger Q|Q\rangle = 1$.

In descriptive terms this expression corresponds to the additional contribution from the interference of the new interaction with the standard one to the weak scattering $b\,u \to c\,d$ in decays of the b hyperons.

2.3 Interference in B^-

The term in $L_{eff}^{(3)}$ with the four-quark operators of the type $(\overline{b}\,\Gamma\,u)(\overline{u}\,\Gamma'\,b)$ corresponding to the weak scattering in decays of the hyperons, when applied to mesons, describes the Pauli interference of the spectator $\overline{u}$ antiquark in B^- meson with that produced in the decay $b \to c\,d\,\overline{u}$. The expression for the effect of the new interaction in this term is written here in the limit of factorization, which in practice amounts to the following substitution:

$$\langle B^-|(\overline{b}\,\Gamma\,u)(\overline{u}\,\Gamma'\,b)|B^-\rangle \to -\frac{f_B^2\,m_b}{288}\,\mathrm{Tr}\,[\Gamma\,\gamma_5\,(1+\gamma\cdot u)]\;\mathrm{Tr}\,[\Gamma'\,(1+\gamma\cdot u)\,\gamma_5] \tag{11}$$

with arbitrary spin and color matrices Γ and Γ', and with the traces running over the spinor and color indices. The quantity f_B in this expression is the B meson annihilation constant.

After these preliminary remarks, the expression for the shift of the total decay rate of B^- due to the interference of the new and the standard interaction is readily calculable, and is given by

$$\delta\Gamma(B^-) = -\frac{G_F^2 m_b^3 f_B^2 |V_{cb}|^2}{4\pi}\,\mathrm{Re}\left[C_+\,(\frac{1}{3}\,h_1 + h_3 - h_2 - 3\,h_4) + C_-\,(\frac{1}{3}\,h_1 - h_3 - h_2 + 3\,h_4)\right] \tag{12}$$

2.4 Contribution of the new interaction to $B_d^0 \to c\,\overline{u}$

With the standard weak interaction the shift of the total decay rate of the B_d^0 meson due to the annihilation process $b\,\overline{d} \to c\,\overline{u}$ is suppressed by the factor m_c^2/m_b^2 for chirality reasons. The hypothetical new interaction, involving c and u of opposite chirality does not carry such suppression. The expression for the (necessarily positive) shift of the total decay rate of B_d^0, quadratic in the new interaction, reads as

$$\delta\Gamma(B_d \to c\,\bar{u}) = |V_{cb}|^2\,\frac{G_F^2\,m_b^3\,f_B^2}{8\pi}\left|\frac{1}{3}\,h_1 + h_2 - 2\,h_3\right|^2\ . \tag{13}$$

3 Estimates of the effects

Clearly, the dependence of the discussed effects in b decays on four parameters h_A leaves a considerable freedom for uncoupling the magnitude of these effects in four specific processes.

For a more constrained discussion, it is assumed here that the new interaction arises from an exchange of a scalar boson ϕ in the diquark channel: $b_R\, u_R \to \phi \to c_L\, d_L$, which fixes the spinor structure of the interaction, normalized at $\mu = m_\phi$. If ϕ is a color (anti)triplet the relation between the constants at that normalization point is $h_1(m_\phi) = h_3 = 3\, h_2 = 3h_4(m_\phi)$, while if the ϕ is a color sextet, the corresponding relation is $h_1(m_\phi) = h_3(m_\phi) = -h_2(m_\phi) = -h_4(m_\phi)$. In either case one has $h_1 = h_3$ and $h_2 = h_4$ and this relation is preserved through the QCD renormalization of the 'centiweak' Lagrangian down to $\mu = m_b$. For this reason in what follows the notation h_S is used for the common value of the coefficients h_1 and h_3 in front of the scalar operators and h_T stands for the common value of the coefficients h_2 and h_4 for the tensor structures. We will not speculate here on apriori relative values of h_S and h_T, and will leave these two constants (at $\mu = m_b$) as free parameters in the present phenomenological analysis.

With this reduction in the number of parameters the expressions of the previous section considerably simplify. In particular, the additional shift of the total decay rate of the B^- meson, given by eq.(12), takes the form[2]

$$\begin{aligned} \delta\Gamma(B^-) &= -\frac{G_F^2 m_b^3 f_B^2 |V_{cb}|^2}{6\pi}\,(2\,C_+ - C_-)\mathrm{Re}[h_S - 3\,h_T] \\ &\approx -0.03\,\mathrm{Re}[h_S - 3\,h_T]\left(\frac{f_B}{200\,MeV}\right)^2 ps^{-1}\ , \end{aligned} \tag{14}$$

and it should be emphasized again that this estimate assumes perfect factorization of the four-quark matrix elements over the B meson.

The formula in eq.(10) for the shift of the decay rate of Λ_b (and the same shift for Ξ_b^0) reduces to

$$\begin{aligned} \delta\Gamma(\Lambda_b) &= \frac{G_F^2 m_b^2 |V_{cb}|^2}{2\pi}\, C_+ \mathrm{Re}[h_S - 3\,h_T]\langle\Lambda_b|(\overline{b}b)(\overline{u}u) + (\overline{b}_i b^j)(\overline{u}_j u^i)|\Lambda_b\rangle \\ &\approx 0.05\,\mathrm{Re}[h_S - 3\,h_T]\left(\frac{\langle\Lambda_b|(\overline{b}b)(\overline{u}u) + (\overline{b}_i b^j)(\overline{u}_j u^i)|\Lambda_b\rangle}{0.04\,GeV^3}\right) ps^{-1}\ . \end{aligned} \tag{15}$$

The matrix element of the four quark operator involved in the latter expression is a source of a major uncertainty. In a naive quark picture the color antisymmetry of the quark wave function would lead to a cancellation between the two terms differing by the 'twist' of the quark colors. However an analysis [6, 2] of similar matrix elements with a product of vector currents (rather than of the scalar densities): $(\overline{Q}\gamma_\mu Q)(\overline{q}\gamma^\mu q)$ and $(\overline{Q}_i\gamma_\mu Q^j)(\overline{q}_j\gamma^\mu q^i)$,

[2]In the numerical estimates here we set $C_=1.35$, $C_+ = C_-^{-1/2} \approx 0.86$.

whose matrix elements are related to differences of lifetimes within the triplet of charmed baryons (Λ_c, Ξ_c^+, Ξ_c^0), reveals that the color antisymmetry relation badly fails, and the value of $0.04\, GeV^3$, used in eq.(15), is well representative at least in the case of vector currents. In the case of the operators with products of scalar densities as in eq.(15) we in fact have no good guidance[3], and the particular value, used in eq.(15) should be considered as an 'educated guess'.

The expression (5) for the additional nonleptonic 'parton' decay rate of a b quark in terms of h_S and h_T reads as

$$\frac{\delta\Gamma_{nl}(b)}{\Gamma_{nl}^{(0)}(b)} = \frac{8}{3}\left(|h_S|^2 + 3|h_T|^2\right) \ . \tag{16}$$

Clearly the ratio $\delta\Gamma(\Lambda_b)/\delta\Gamma_{nl}(b)$ is maximized, if one assumes that both h_S and h_T are real, h_S is positive, and $h_T = -h_S$[4]. Taking as sample values $h_S = -h_T = 0.15$, and leaving aside the uncertainties in the matrix elements involved in equations (14) and (15), one estimates the discussed shifts of the decay rates due to the new hypothetical interaction as $\delta\Gamma(\Lambda_b) \approx 0.03\, ps^{-1}$, $\delta\Gamma(B^-) \approx -0.02 ps^{-1}$, and $\delta\Gamma_{nl}(b) \approx 0.24\, \Gamma_{nl}^{(0)}(b)$. In relative terms, these estimates correspond to an additional enhancement of the Λ_b decay rate by about 5% of the decay rate of the B_d^0 meson, a reduction of the B^- decay rate by about 3 %, and an increase in the overall non-leptonic decay rate of the b hadrons by (12 – 18)%. The latter number is lower than the relative value of the additional decay rate with respect to $\Gamma_{nl}^{(0)}(b)$, due to the contribution to the total nonleptonic rate of the decay $b \to c\,\overline{c}\,s$. The range of values corresponds to uncertainty in the effect of yet uncalculated LLO and NLO QCD corrections to the b decay rate through the discussed hypothetical interaction.

The additional contribution to the total decay rate of the B_d^0 meson, described by eq.(13), is then estimated as

$$\delta\Gamma(B_d) = \frac{G_F^2 m_b^3 f_B^2 |V_{cb}|^2}{8\pi}\, |h_T - \frac{5}{3}\, h_S|^2 \approx 0.009 \left(\frac{f_B}{200\, MeV}\right)^2 ps^{-1} \ , \tag{17}$$

which constitutes about 1.5% of the total decay rate.

[3]Except for the obvious remark that in the heavy quark term $(\overline{Q}\gamma^0 Q)$ is equivalent to $(\overline{Q}Q)$ in the leading in m_Q approximation.

[4]The latter relation is the one corresponding to an interaction induced by an exchange of a color sextet scalar ϕ, if one neglects the QCD running effects.

4 Discussion and Summary

The estimates of the previous section, with all the uncertainty arising from the present poor knowledge of the hadronic matrix elements, demonstrate that an introduction of a new 'centiweak' interaction, suggested in eq.(2), might slightly modify theoretical estimates of the observable effects in b hadron decays, possibly putting them closer to the current experimental data. An additional reduction of the ratio $\tau(\Lambda_b)/\tau(B_d^0)$ by about 5% would place the theoretical prediction within less than $2\,\sigma$ from the experimental number. An increase by about 15% of the overall nonleptonic decay rate of the b hadrons might be helpful in understanding the relatively low experimental value for the semileptonic branching ratio $B_{sl}(B)$. Moreover this increase comes from a decay channel with a single c quark, thus effectively diluting the branching ratio for the channel $b \to c\,\overline{c}\,s$ and thus somewhat *reducing* the average charm yield n_c. This is contrary to the analyses, where the enhancement of the total nonleptonic decay is achieved by increasing the rate in the channel $b \to c\,\overline{c}\,s$, thereby effectively correlating a low $B_{sl}(B)$ with a larger, than experimentally observed, value of n_c. (For the most recent review of this issue see Ref.[3].)

As discussed, simultaneously with enhancing the decay of Λ_b the new interaction additionally suppresses the decay rate of $B^\pm$ with a 'sample' magnitude of the suppression being about 3%. Combined with about 1.5% enhancement of the decay of B_d, this effect might increase the ratio $\tau(B^\pm)/\tau(B_d)$ by about 4%. This is to be compared with the current experimental number [1]: $\tau(B^\pm)/\tau(B_d) = 1.06 \pm 0.03$ and the 'preferred' theoretical values: $\tau(B^\pm)/\tau(B_d) - 1 \approx 0.04$ [2] and $\tau(B^\pm)/\tau(B_d) - 1 \approx 0.05$ [3] (both theoretical numbers are normalized to $f_B = 200\,MeV$). Therefore, if with improved experimental data this ratio of lifetimes moves toward the upper edge of the currently allowed range, this can be interpreted as a manifestation of the discussed new interaction.

The slightly more than one percent enhancement of the decay rate of the B_d meson, might seem insignificant. However, it should be noticed that the standard theoretical analysis places this decay rate well within 1% from the average decay rate of the B_s mesons: $|\tau(B_d)/\tau(B_s) - 1| < 0.01$. Thus an experimental observation of a breaking of this 'one percent rule' may serve as another signal of the new interaction.

Naturally, a speculation about a new four-quark interaction necessarily invites concerns about its compatibility with other known phenomenology, in particular with the limits on the 'flavor changing neutral currents' (FCNC). The interaction in eq.(2) can in principle induce, through interference with the standard weak interaction, effective FCNC in two neutral

channels: $b\,\overline{d}$ and $c\,\overline{u}$. Thus there can appear a contribution to the $B_d - \overline{B}_d$ and $D^0 - \overline{D}^0$ oscillations. However, for the $B_d - \overline{B}_d$ case, the transition $b\,\overline{d} \to c\,\overline{u}$ involves a right-chiral u quark, which effectively decouples from the weak interaction, up to effects proportional to the tiny m_u. Therefore the contribution of the new interaction to the $B_d - \overline{B}_d$ oscillations is practically nonexistent. The 'centiweak' transition $c\,\overline{u} \to b\,\overline{d}$ involves a right handed b quark and thus can be followed by the weak transition $b\overline{d} \to u\,\overline{c}$ (proportionally to $m_b\, V_{bu}\, V_{cd}$). A parametric estimate of this contribution to the $D^0 - \overline{D}^0$ oscillation rate is

$$\delta m_D \sim (G_F^2/\pi^2)\, |h_A|\, m_c^2\, m_b\, |V_{bu}|\, |V_{cd}|\, f_D^2 \sim 10^{-3}\, \Gamma(D^0)\ , \tag{18}$$

which is well below the current upper limit on $\delta m_D/\Gamma(D^0)$.

The compatibility of the 'centiweak' interaction with the current limits on FCNC, which is argued here for the specific flavor structure shown in eq.(2), may become invalidated if other flavor combinations are added in the same manner. As is already mentioned, it might appear 'unnatural' to assume that the considered 'centiweak' interaction is significant only for the specific flavors as suggested by eq.(2). However on the technical side such assumption is perfectly legitimate. The considered interaction is introduced here purely phenomenologically, leaving aside possible reasons for its origin within more general models of a 'New Physics', since the main goal of the present paper is to demonstrate the mechanism, allowing an interference of a new interaction with the standard one due to the breaking of chirality of the light quarks in hadrons. The only obvious reference to the origin of the discussed interaction, made here, is that it can arise from an exchange of an SU(2) singlet scalar ϕ with color properties of a diquark. Clearly, an introduction of a massive SU(2) singlet scalar field in the Standard Model does not affect the precision tests of the electroweak theory. Given that the strength of the induced four quark interaction is of order $10^{-2}\, G_F$, the mass of the ϕ can easily be as high as in the several TeV range without the need of assuming its large Yukawa couplings.

In summary. It is demostrated that an explanation of the apparently low value of the ratio of the lifetimes $\tau(\Lambda_b)/\tau(B_d)$ as an effect of new 'centiweak' four-quark interaction, is at least a 'logical possibility', which does not appear to be in conflict with other known phenomenology. Moreover, a moderate additional contribution from the new interaction to the nonleptonic decay rate of a b quark may be helpful in understanding a somewhat low semileptonic branching ratio $B_{sl}(B)$. For the $B^\pm$ and B_d^0 mesons the model predicts additonal effects in the lifetimes, which are still within the experimental errors, but which might become testable with more precise data.

5 Acknowledgements

I acknowledge a warm hospitality of the Aspen Center for Physics, where preliminary estimates for this paper were done. This work is supported in part by DOE under the grant number DE-FG02-94ER40823.

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